

We claim:

1. A method of removing contaminants from a hydride or a reactive gas stream comprising contacting said contaminated gas stream with a purifier material for a period of time sufficient to reduce the level of said contaminants to parts-per-billion levels, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of one or more reduced forms of a metal oxide.
2. The method of claim 1, wherein the oxidation state of said metal of said purifier thin layer is lower than the maximum oxidation state of said metal.
3. The method of claim 2, wherein said thin layer of said purifier material further contains said metal in a zero oxidation state.
4. The method of claim 1, wherein said metal oxide is selected from the group consisting of oxides of vanadium, molybdenum, antimony, bismuth, tin, cerium, chromium, cobalt, copper, tungsten, and mixtures thereof.
5. The method of claim 1, wherein said substrate is selected from the group consisting of alumina, amorphous silica-alumina, silica (SiO_2), aluminosilicate molecular sieves, titania (TiO_2) and zirconia (ZrO_2).
6. The method of claim 1, wherein said hydride gas is selected from the group consisting of ammonia (NH_3), arsine (AsH_3), phosphine (PH_3), germane (GeH_4), silane (SiH_4), methyl silane, t-butyl arsine, t-butyl phosphine, and alkyl and halide derivatives thereof.
7. The method of claim 1, wherein said reactive gas is selected from the group consisting of trimethyl aluminum, trimethyl gallium, and trimethyl indium.
8. The method of claim 1, wherein said contaminants are selected from the group consisting of oxygen and moisture.
9. The method of claim 1, wherein said purifier material is prepared by the method comprising:
 - (a) providing a precursor comprising a nonreactive substrate having deposited thereon a thin layer of a metal of a first oxidation state;
 - (b) heating said precursor under a flow of nitrogen at a temperature between about 100°C and 600°C for a period of time; and
 - (c) treating said precursor from step (b) under reductive conditions sufficient to reduce the oxidation state of said metal of said precursor thin layer, thereby producing said purifier material, wherein the metal of the purifier thin layer has a second oxidation state that is lower than said first oxidation state.

IM 10. The method of claim 9, wherein said metal of a first oxidation state is selected from the group consisting of an oxide, a salt, an acid, an organic complex, ^{or} of an inorganic complex of said metal.

11. The method of claim 9, wherein said precursor thin layer is deposited on said substrate by a method selected from the group consisting of incipient wetness impregnation, ion exchange methods, vapor deposition, spraying of reagent solutions, co-precipitation, and physical mixing.

12. The method of claim 9, wherein said precursor is heated under a flow of nitrogen for about 1 to 200 hours.

112 13. The method of claim 9, wherein said precursor is heated under a flow of ^{cl. 9 said nitrogen} hydrogen for about 1 to 200 hours.

14. The method of claim 1, wherein the total surface area of said thin layer of said purifier material is less than 100 m²/g.

15. The method of claim 14, wherein total surface area of said thin layer of said purifier material is between about 10 and 95 m²/g.

16. The method of claim 1, wherein said purifier material comprises between about 1 to 20% of said reduced forms of said metal oxide and about 80-99% of said substrate.

(17.) A method of removing contaminants from a hydride gas stream comprising contacting said contaminated gas stream with a purifier material for a period of time sufficient to reduce the level of said contaminants to parts-per-billion levels, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of one or more reduced forms of an oxide of a metal, said thin layer having a total surface area less than 100 m²/g.

18. The method of claim 17, wherein total surface area of said thin layer of said purifier material is between about 10 and 95 m²/g.

19. The method of claim 17, wherein the oxidation state of said metal of said purifier thin layer is lower than the maximum oxidation state of said metal.

20. The method of claim 19, wherein said thin layer of said purifier material further contains said metal in a zero oxidation state.

(21.) A method of removing contaminants from a hydride gas stream comprising contacting said contaminated gas stream with a purifier material for a period of time sufficient to reduce the level of said contaminants to parts-per-billion levels, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of one or

- more reduced forms of an oxide of a metal, wherein the oxidation state of said metal in said purifier thin layer is lower than the maximum oxidation state of said metal.
22. The method of claim 21, wherein said thin layer of said purifier material further contains said metal in a zero oxidation state.
 23. The method of claim 21, wherein the total surface area of said thin layer of said purifier material is less than $100 \text{ m}^2/\text{g}$.
 24. The method of claim 23, wherein total surface area of said thin layer of said purifier material is between about 10 and $95 \text{ m}^2/\text{g}$.
 25. A method of preparing a purifier material for removing contaminants from a hydride gas stream, said method comprising:
 - (a) providing a coated precursor comprising a nonreactive substrate having deposited thereon a thin layer of a metal of a first oxidation state;
 - (b) heating said precursor under a flow of nitrogen at a temperature between about 100°C and 600°C for a period of time; and
 - (c) treating said precursor from step (b) under reductive conditions sufficient to produce said purifier material comprising said nonreactive substrate having deposited thereon a thin layer of one or more reduced forms of an oxide of said metal of a second oxidation state, wherein said second oxidation state is lower than said first oxidation state.
 26. The method of claim 25, wherein step (c) comprises heating said precursor from step (b) under a flow of 100% hydrogen at a temperature between about 300°C and 600°C for between about 1 and 200 hours.
 27. The method of claim 25, wherein step (c) comprises heating said precursor from step (b) under a flow of a gaseous mixture comprising from about 0.1% up to 100% hydrogen, the remainder of said mixture comprising a gas selected from the group consisting of an inert gas, a nonreactive gas, and a reactive gas.
 28. The method of claim 25, wherein step (c) comprises heating said precursor from step (b) under a flow of a gaseous mixture comprising 100% ammonia at a sufficient temperature for a time sufficient to produce said purifier material.
 29. The method of claim 25, wherein step (c) comprises heating said precursor from step (b) under a flow of a gaseous mixture comprising from about 0.1% up to 100% ammonia, the remainder of said mixture comprising a gas selected from the group consisting of an inert gas, a nonreactive gas, and hydrogen.

10003179-103101

30. The method of claim 25, wherein step (c) comprises contacting said precursor from step (b) with a reducing agent.
31. The method of claim 30, wherein said reducing agent is selected from the group consisting of hydrazine, a hydrazine, and lithium aluminum hydride.
32. The method of claim 25, wherein the oxidation state of said metal in said purifier thin layer is lower than the maximum oxidation state of said metal.
33. The method of claim 32, wherein said thin layer further comprises said metal in a zero oxidation state.
34. The method of claim 25, wherein said metal is selected from the group consisting of vanadium, molybdenum, antimony, bismuth, tin, cerium, chromium, cobalt, copper, tungsten, and mixtures thereof.
35. The method of claim 25, wherein said substrate is selected from the group consisting of alumina, amorphous silica-alumina, silica (SiO_2), aluminosilicate molecular sieves, titania (TiO_2) and zirconia (ZrO_2).
36. The method of claim 25, wherein said hydride gas is selected from the group consisting of ammonia (NH_3), arsine (AsH_3), phosphine (PH_3), germane (GeH_4), silane (SiH_4), methyl silane, t-butyl arsine, t-butyl phosphine, and alkyl and halide derivatives thereof.
37. The method of claim 25, wherein said contaminants are selected from the group consisting of oxygen and moisture.
38. The method of claim 25, wherein the total surface area of said thin layer of said purifier material is less than $100 \text{ m}^2/\text{g}$.
39. The method of claim 38, wherein total surface area of said thin layer of said purifier material is between about 10 and $95 \text{ m}^2/\text{g}$.
40. The method of claim 25, wherein said purifier material comprises between about 1 to 20% of said reduced forms of said metal oxide and about 80-99% of said substrate.
41. A purifier material prepared by the method of claim 25.
42. The purifier material of claim 41, wherein the total surface area of said thin layer of said purifier material is less than $100 \text{ m}^2/\text{g}$.
43. The purifier material of claim 42, wherein total surface area of said thin layer of said purifier material is between about 10 and $95 \text{ m}^2/\text{g}$.
44. The purifier material of claim 41, wherein the oxidation state of said metal of said purifier thin layer is lower than the maximum oxidation state of said metal.

10003179-103101

product
by
process

45. The purifier material of claim 44, wherein said thin layer further contains said metal in a zero oxidation state.

46. The purifier material of claim 41, wherein said purifier material is regenerable.

112 47. A purifier material for removing contaminants from a hydride gas stream, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of reduced forms of an oxide of said metal. lab

48. The purifier material of claim 47, wherein the total surface area of said thin layer of said purifier is less than 100 m²/g.

49. The purifier material of claim 48, wherein ^{the} total surface area of said thin layer of said purifier material is between about 10 and 95 m²/g.

112 50. The purifier material of claim 47, wherein the oxidation state of said metal in said purifier thin layer is lower than the maximum oxidation state of said metal.

112 51. The purifier material of claim 50, wherein said thin layer further contains said metal in a zero oxidation state.

112 52. The purifier material of claim 47, wherein said metal is selected from the group consisting of vanadium, molybdenum, antimony, bismuth, tin, cerium, chromium, cobalt, copper, tungsten, and mixtures thereof.

53. The purifier material of claim 47, wherein said substrate is selected from the group consisting of alumina, amorphous silica-alumina, silica (SiO₂), aluminosilicate molecular sieves, titania (TiO₂) and zirconia (ZrO₂).

54. The purifier material of claim 47, wherein said purifier material is regenerable.

112 55. A purifier material for removing contaminants from a hydride gas stream, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of reduced forms of an oxide of said metal, wherein the total surface area of said thin layer is less than 100 m²/g. lab

56. The purifier material of claim 55, wherein total surface area of said thin layer of said purifier material is between about 10 and 95 m²/g.

112 57. The purifier material of claim 55, wherein the oxidation state of said metal of said purifier thin layer is lower than the maximum oxidation state of said metal.

112 58. The purifier material of claim 57, wherein said thin layer further comprises said metal in a zero oxidation state.

112 59. The purifier material of claim 55, wherein said metal is selected from the group consisting of vanadium, molybdenum, antimony, bismuth, tin, cerium, chromium, cobalt, copper, tungsten, and mixtures thereof.

10003179-103101

60. The purifier material of claim 55, wherein said substrate is selected from the group consisting of alumina, amorphous silica-alumina, silica (SiO_2), aluminosilicate molecular sieves, titania (TiO_2) and zirconia (ZrO_2).
- 112 61. A purifier material for removing contaminants from a hydride gas stream, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of reduced forms of an oxide of said metal, wherein the oxidation state of said metal of said purifier thin layer is lower than the maximum oxidation state of said metal.
62. The purifier material of claim 61, wherein said thin layer further comprises said metal in a zero oxidation state.
63. The purifier material of claim 62, wherein the total surface area of said thin layer of said reduced forms of said metal oxide is less than $100 \text{ m}^2/\text{g}$.
64. The purifier material of claim 61, wherein total surface area of said thin layer of said purifier material is between about 10 and $95 \text{ m}^2/\text{g}$.
65. A purifier material for removing contaminants from a hydride gas stream, said purifier material comprising a nonreactive substrate having deposited thereon a thin layer of reduced forms of an oxide of said metal, wherein the total surface area of said thin layer is less than $100 \text{ m}^2/\text{g}$ and wherein the oxidation state of said metal is lower than the maximum oxidation state of said metal, wherein said metal is selected from the group consisting of vanadium, molybdenum, antimony, bismuth, tin, cerium, chromium, cobalt, copper, tungsten, and mixtures thereof.
- obj 66. A method of preparing a purifier material for removing contaminants from a hydride gas stream, said method comprising:
- (a) providing a precursor comprising a nonreactive substrate having deposited thereon a thin layer of a first form ^{of} a metal, wherein said first form is other than a metal oxide;
 - (b) heating said precursor under a flow of nitrogen at a temperature between about 100°C and 600°C for a period of time; and
 - (c) treating said precursor from step (b) under conditions sufficient to convert said first form of said metal to an oxide of said metal, thereby producing a purifier material comprising a nonreactive substrate having a thin layer of a metal oxide deposited thereon, wherein the oxidation state of said metal oxide is the same as the oxidation state of said first form of said metal, and wherein the oxidation state of said metal of said purifier thin layer is lower than the maximum oxidation state of said metal.